Status of Texas Birmingham Active Target (TeBAT) development

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In order to measure nuclear reactions with exotic beams to elucidate the nature of nuclear force and to understand the origin of elements, we are developing a state-of-the-art detector system to achieve unprecedented precision of charged particle tracks and vertex position. This new device, Texas Birmingham Active Target (TeBAT), is the active target time projection chamber and it will allow studies for benchmarking predictions of contemporary microscopic models of atomic nuclei that start from QCD and nucleon-nucleon interactions. While the TeBAT is similar to the existing TexAT detector [1] in terms of geometry, the major difference will be a new Micro-MEsh Gaseous detector (micromegas) design that is a crucial part of the time projection chamber. The TeBAT will consist of a micromegas, a Silicon detector array and a CsI(Tl) detector array as shown in Fig. 1._It will provide a 3D particle track of a charge particle and measure its total energy deposition in Si and CsI(Tl), if the particle has enough energy escaping the active TPC volume and hitting the Si detector.

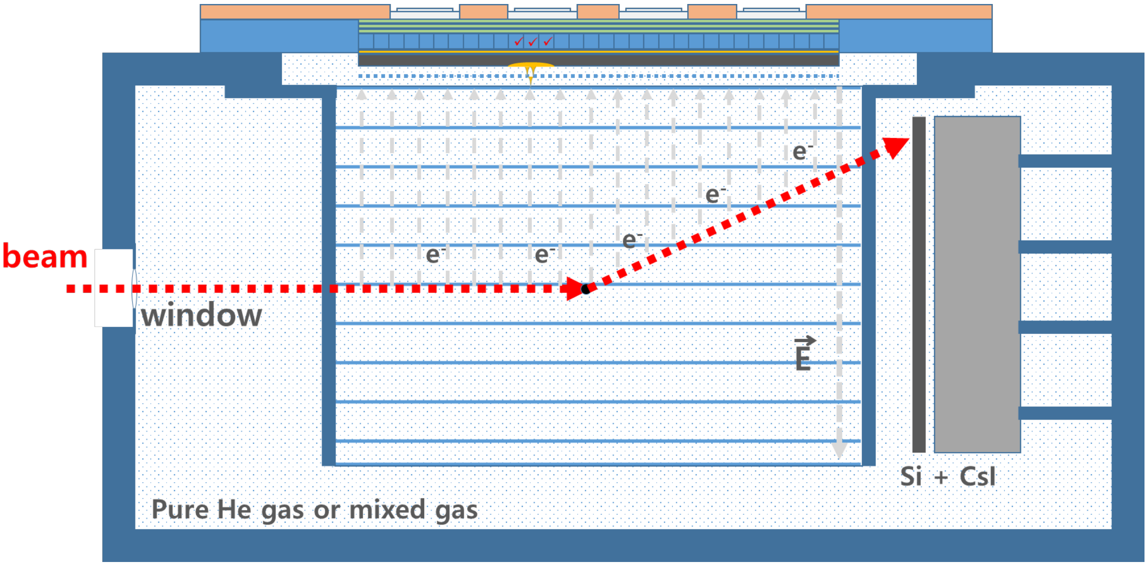

Fig. 1. A conceptual design of TeBAT detector. The Micromegas PCB board is sitting on top of the scattering chamber and the active area is placed on top of the field cage. The Silicon detector array is surrounding the field cage to detect particles escaping the field cage and the CsI(Tl) detectors are placed at the back of the Silicon detector array to detect silicon-punch-through particles.

The TeBAT will utilize a new technology on the micromegas, resistive layer, which will allow for position resolution as good as 200 microns. This will result in unprecedented angular resolution on the order of 0.1 degrees, which is critical for many nuclear reaction studies. Ionized electrons produced by particles will be drifted to the micromegas and amplified by the electron avalanche process. Then, the amplified electrons arriving at the resistive layer will induce signals on readout pads as demonstrated in Fig. 1. Depending on the surface resistivity and the distance between the resistive layer and the readout pad, the shape of the induced signal and the number of pad spread are significantly changed due to its RC constant. In order to collect spread induced signals and to reach a good position resolution, 7056 (84x84) readout pixels of 3x3 mm^2 are made on the board.

The size of the micromegas PCB board will be 400x400 mm^2 and its active area will be 252x252 mm^2. We use an "open" design. The micromegas detector will be attached to the scattering chamber directly and will also serve as a top flange. To accommodate this arrangement we will use a 1/2 inch thick stainless steel stiffener plate glued onto the micromegas board to prevent a deformation of the micromegas by the differential pressure between one atmosphere of air outside the chamber and vacuum or low pressure inside the chamber. To provide a different gain between heavy particles (beams and recoils) and light particles due to different energy loss in the gas, an additional detector, Gaseous Electron

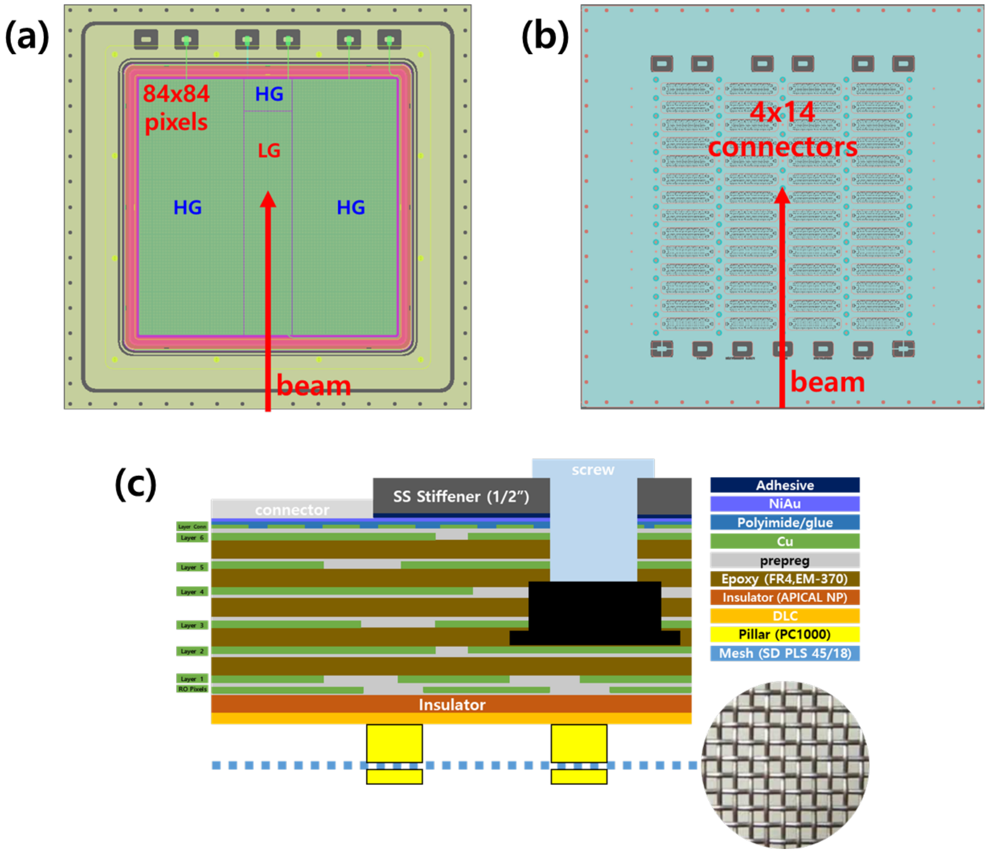

Fig. 2. (a) A micromegas design from the view of the resistive layer. 4 different gains of the GEM are also shown on top of the active area. (b) a micromegas design from the view of the connector side. (c) a conceptual drawing of micromegas layers colored by materials. The layer thickness in the drawing is not scaled. The microscopic image of the Mesh is shown next to the mesh layer. The screw will support the attachment between the PCB board and the stiffener.

Multiplier (GEM), will be used. It will be divided into 4 areas which can have independent gain, separately. Detailed PCB layout is shown in Fig. 2.

The flexible printed circuits (FPC) cable design is also under progress in order to carry signals from a large number of channels without any cross talks among channels. The readout of signals will be processed by the General Electronics for TPC (GET) [2]. The GET electronics for the TeBAT detector will consist of 1 microTCA crate, 1 Mutant trigger module, 8 CoBo communication modules and 28 AsAd motherboards. Detailed description of the GET electronics is explained in Ref. [1] and [2]. Digitized waveforms of signals are transferred from the AsAd boards to a computer storage by Ganil Data Acquisition System (Ganil DAQ) [3]. In order to analyze the recorded data efficiently, we decided to develop a shared library, TeBATlib, focused on the TPC data analysis. The following libraries are being built:

1. TeBATSim: a simulation tool of the TeBAT detector configuration using GEANT4 libraries,
2. TeBATResponse: an experimental data emulator using the output of the TeBATSim,
3. TeBATAnalysis: an offline data analysis tool and data viewer,
4. TeBATLive: an online data analysis tool.

The TeBAT Analysis Software Package project is divided into sub-groups by each software to concentrate on each task, while libraries made by one group will be shared by others.

In order to simulate the detector response and to model the induced signals produced by the resistive layer, the electric field maps of the mesh and micromegas are under calculation by outsourcing company, Radiation Detection and Imaging (RDI). The field map will be used as an input for the GARFIELD simulation to reproduce the charge distribution on readout pads.

In summary, our new state-of-the-art detector, TeBAT, is under development and this device will provide a position resolution of 200 micron. A new technique, resistive layer, has been applied to the micromegas. The active area of the detector will be 252x252 mm^2 and the GEM will be used to provide different gains for 4 sections. The final determination of DLC properties, layer stack of the FPC cable will be made soon in order to submit a production of the device. Also, the TeBAT analysis software package will be developed as well before the completion of the micromegas board.

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[3] A. Boujrad and F. Saillant, 2000 IEEE Nuclear Science Symposium, Conference Record (Cat. No.00CH37149), Lyon, 2000, pp. 12/192-12/193 vol.2.